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HEADQUARTERS
QUARTERMASTER RESEARCH & ENGINEERING COMMAND
U S ARMY

TECHNICAL REPORT
EP-66

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DAC

CALORIC INTAKE DURING PROLONGED COLD EXPOSURE

QUARTERMASTER RESEARCH & ENGINEERING CENTER
ENVIRONMENTAL PROTECTION RESEARCH DIVISION

SEPTEMBER 1957

NATICK, MASSACHUSETTS

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QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
OFFICE OF THE COMMANDING GENERAL
NATICK, MASSACHUSETTS

30 September 1957

Major General Andrew T. McNamara
The Quartermaster General
Washington 25, D.C.

Dear General McNamara:

This study, "Caloric Intake during Prolonged Cold Exposure," is a report of one of a series of experiments to assess the impact of climate on the food requirements of soldiers.

The report evaluates the effect of cold on caloric intake of nude, sedentary men, thus eliminating the complicating effects of clothing and exercise. It was found that the daily food intake at 60°F. was approximately 22% greater than at 80°F. The results of the study indicate that when men are continuously chilled they require more food because of the increased energy expenditure due to shivering.

Application of this study should enable planners and logistics personnel to more exactly determine the food requirements in cold climates, thereby reducing waste, and economizing in the Army supply system.

Sincerely yours,

C. G. Calloway
C. G. CALLOWAY
Brigadier General, USA
Commanding

1 Incl
EP-66

HEADQUARTERS QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

ENVIRONMENTAL PROTECTION RESEARCH DIVISION

Technical Report
EP-66

CALORIC INTAKE DURING PROLONGED COLD EXPOSURE

P F Iampietro, Ph D David E Bass, Ph D Elsworth R Buskirk, Ph D

PHYSIOLOGY BRANCH

Project Reference
7-83-01-005B

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FOREWORD

The impact of cold *per se* on caloric intake cannot be precisely assessed unless the complicating effects of clothing and activity are eliminated. This report contains information on the effects of prolonged cold exposure on the caloric intake of nude, sedentary men. From studies of this nature it is possible to evaluate the separate and combined effects of many of the factors which influence caloric intake.

AUSTIN HENSCHEL, Ph.D.
Chief
Environmental Protection Research Division

Approved:

JAMES C. BRADFORD, Colonel, QMC
Commanding Officer
QM R and E Center Laboratories

A. STUART HUNTER, Ph.D.
Scientific Director
QM Research & Engineering Command

Abstract

The effects of continuous cold stress on caloric intake and energy expenditure of five men were studied. Cold stress consisted in living in a chamber at 60°F. (15.6°C.) for 14 days. The men wore only shorts and were allowed minimal physical activity. The cold period was preceded and followed by two weeks at 80°F. (26.7°C.). Activity and dietary composition were the same for all periods.

During the control and recovery periods caloric intake averaged 2287 and 2405 Calories/man/day and weight loss averaged 1.75 and 0.90 Kg/man, respectively. During the cold period caloric intake was 2870 Calories/man/day; there was no weight loss for this period.

When corrected for weight loss, caloric intakes averaged 2661 and 2678 Calories/man/day for the control and recovery periods, respectively. An increase in resting energy expendit re of about 140 Calories/man/12-daytime-hours was observed in the cold period. The increased caloric intake in the cold was associated with an increased energy expenditure due to non-detectable shivering and occasional frank shivering. There was no evidence that cold stress imposed additional caloric requirements apart from those resulting from increased muscle activity.

CALORIC INTAKE DURING PROLONGED COLD EXPOSURE

1. Introduction

It is generally believed that living in cold regions, e.g., subarctic, Arctic, is associated with caloric intakes which are greater than those observed in more temperate climates. Thus, Johnson and Kark[1] reported that men living in the subarctic (mean ambient temperature −30°F. (−34°C.)) consumed up to 5000 Calories (kcals) daily as compared with daily intakes of 3000 Calories in hot environments.

However, recent work has indicated that climate *per se* has little influence on the caloric intake of soldiers in the field.[2,3] In these studies a group of men living in the subarctic was compared with a group performing similar daily activities in a desert environment. It was found that although the group in the Arctic consumed from 600 to 800 Calories per day more than the desert group, the higher caloric intake in the subarctic appeared to be related to a greater energy expenditure; this was due largely to the encumbrance of Arctic clothing and differences in terrain and ground cover over which the men walked, rather than to an effect of cold. It was found that resting oxygen consumption ($\dot{V}_{O_2}$), measured in comfortable ambient conditions during the course of the day, was not influenced by climate; that is, $\dot{V}_{O_2}$ was similar in these climates.

The assessment of caloric requirements for cold climates is not a simple problem. It is impossible in a field situation to separate the impact of cold stress from the effects of the heavy, cumbersome clothing which must necessarily be worn. In addition, the micro-climate to which the individual's body is exposed often bears no relationship to the total ambient environment. The present study was designed to eliminate clothing and activity as variables, in order to obtain information concerning the effects of cold stress *per se* on caloric intake.

2. Methods

Five men lived in a room at 60°F. (15.6°C.) for two weeks, without clothing except for cotton shorts, and were allowed only minimal activity, e.g., playing cards, reading, writing, watching TV or movies. Windspeed was less than 1 mph and relative humidity was 50%. The two weeks at 60°F. were preceded and followed by two weeks at 80°F. (26.7°C.) During the cold period, each subject was allowed one woolen Army blanket at night. Activity and dietary compositions were the same for all periods. The diet contained the following items: (a) a high calorie, chocolate-flavored milk drink, (b) bread and butter, (c) starch jelly bar, and (d) jam. (See Table II, Appendix) In addition, black coffee was given at each meal and a multi-vitamin supplement was given morning and evening. All items, except the milk drink, were allowed as much as desired at meal times. Accurate

records were kept of the amount of each component eaten and caloric intakes were calculated from these records.

Resting oxygen consumption ($\dot{V}_{O_2}$) was measured at intervals during the day with a Sanborn Waterless Metabulator. These values were used to calculate energy expenditure. Nude body weights were measured each morning after the subject had voided.

3. Results

For the purposes of this paper, the first 6 days of the control period will be disregarded, since this was a transition period between a conventional diet and the one used in this study. Caloric intake during the second week of the control period averaged 2287 Calories/man/day (Figure 1 and Table IV, Appendix); the daily individual intake ranged from 1589 to 2874 Calories. Body weight loss during the same period averaged 1.75 Kg/man (Figure 2 and Table III, Appendix).

During the cold period caloric intake increased. The mean daily intake was 2870 Calories/man; the daily individual intake ranged from 1831 to 4178 Calories. There was no change in mean body weight during this period; mean body weights on the first and last day of the cold period were 67.83 and 67.76 Kg, respectively.

During the recovery period caloric intake again fell off. The mean daily intake was 2405 Calories/man; the daily individual intake ranged from 1146 to 3237 Calories. Body weight decreased an average of 0.9 Kg/man during the recovery period. Thus, the men ingested an average of 525 Calories/man/day more in the cold than in the control and recovery periods.

Energy expenditure was calculated for the twelve hours of the day covered by measurements of $\dot{V}_{O_2}$. These calculations do not include the extra energy expenditure above resting, e.g., eating (specific dynamic action peaks), getting washed. Table I shows that resting energy expenditures during the day in the control, cold and recovery periods were 894, 1030, and 885 Calories/man/day, respectively. There was, therefore, an average increase in energy expenditure of 140 Calories/man/day in the cold period.

In order to estimate caloric turnover, a correction must be applied for the caloric equivalent of any weight changes which occur during an experimental period. Such corrections were made for the weight lost during the control and recovery periods; since there was essentially no weight change in the cold, no correction was applied to the observed caloric intake during that period. The caloric equivalent for weight loss has been taken as 3.5 Calories per gram: this represents an average of values cited by others.[2,4,5] The corrected caloric intake was calculated for the last 7 days of the control period and for all days of the recovery period. When caloric intakes are thus corrected, the intakes for the control and recovery periods were 2661 and 2678 Calories/man/day, respectively (Table I).

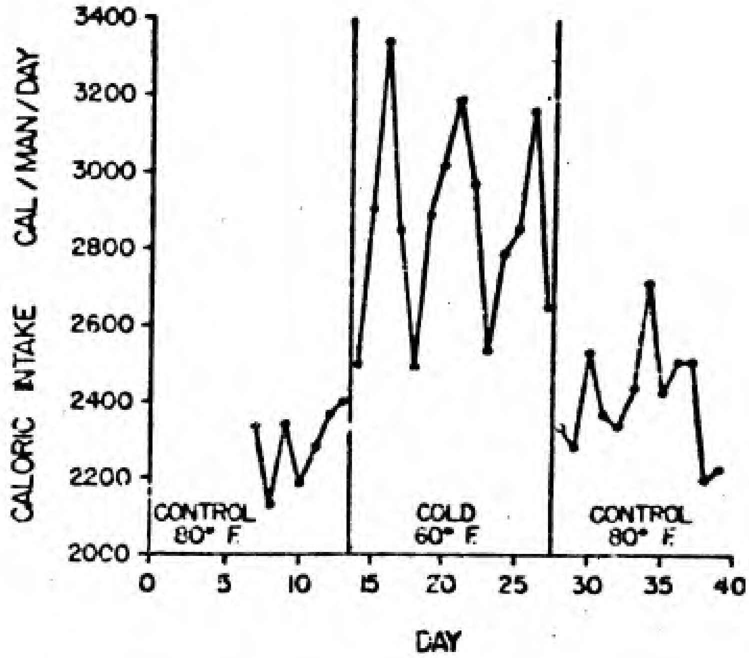

Figure 1. Daily caloric intake. Points represent the means of 5 men.

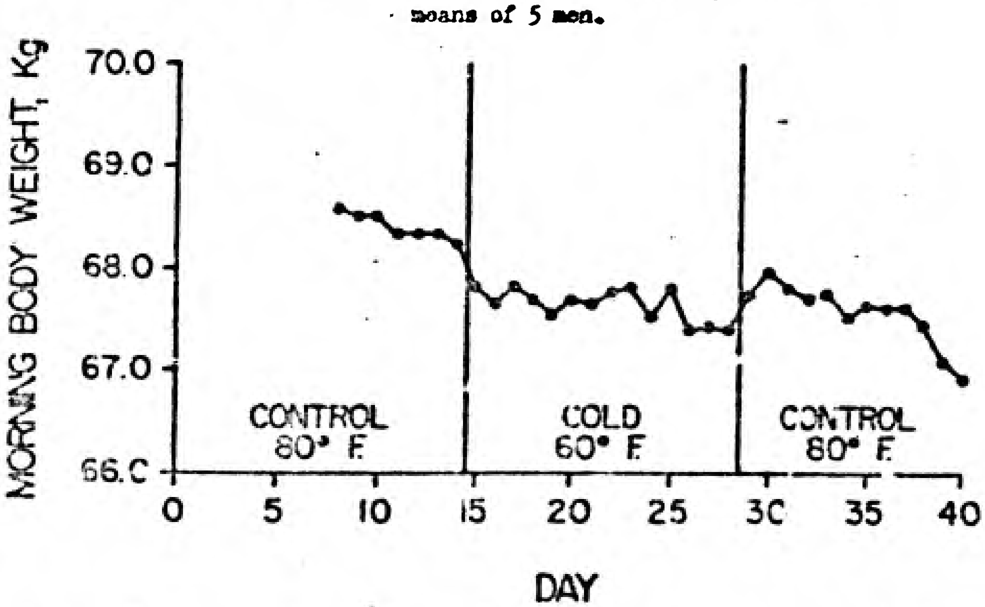

Figure 2. Morning body weight. Points represent the means of 5 men.

The corrected change in caloric intake between control-recovery and cold periods is, therefore, 200 Calories, which agrees well with the results obtained from $\dot{V}O_2$ measurement.

4. Discussion

It might appear, at first glance, that exposure to a temperature of 60°F. is not a sever cold stress. However, experience in this laboratory has shown that when nude and sedentary men are exposed to this temperature for a prolonged period of time, there is marked subjective discomfort and mean skin temperature may fall as much as 7 degrees (F) below that observed at 78 to 80°F. Prolonged chilling of this degree may be much more severe than that experienced under most conditions in the subarctic, where men are warmly dressed when outdoors and are exposed to cold for only short periods of time.[2,6] Therefore, it appeared likely that effects of cold stress *per se* on caloric intake should be revealed in the present study. It is recognized that more severe chilling would probably cause a greater increase in energy expenditure and caloric intake than was observed in this study. However, it is questionable whether appreciably greater cold stress could be tolerated for prol[illegible]d periods.

From the results p[illegible]ented here it would appear that the increased caloric intake in th[illegible] cold is associated with the measured increase in resting $\dot{V}O_2$ (Table I), the latter probably being the result of increased muscle activity, e.g., non-detectable shivering and occasional frank shivering. Although the increase in $\dot{V}O_2$ was based on measurements obtained only during the 12 daytime hours, it is likely that this increase, about 140 Calories/man, represents the total difference for the entire 24-hour period. Since the men slept comfortably under a blanket at night, $\dot{V}O_2$ during these hours was probably not different from that of corresponding hours of the control period.

The data of Johnson and Kark[1] indicate that for every degree (F) fall in mean ambient temperature there is a 20 Calorie increase in daily caloric intake. In the present study the uncorrected caloric intake shows a difference of 525 Calories for a 20 degree drop in temperature (26 Calories/°F). However, when caloric intake is "corrected" for weight loss, this value becomes 200 Calories (10 Calories/°F). In comparing our findings with the above authors, the following points must be borne in mind: (a) their caloric intakes were not corrected for any weight changes which may have occurred, (b) physical activity was not well-defined, (c) caloric intake was assessed by the mess inventory method.

The results of the present study, performed under laboratory conditions, support the recent findings from this laboratory[2,3] that when similar daily activities are performed, the major difference in caloric intake between subarctic and desert environments is due mainly to the higher energy cost imposed by the cumbersome Arctic clothing worn in cold regions.

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6. Acknowledgements

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APPENDIX

TABLE I: SUMMARY OF CALORIC INTAKE AND ENERGY EXPENDITURE
(mean of 5 men)

	Period		
	Control	Cold	Recovery
Caloric Intake (Calories/man/day)	2287	2870	2405
Weight Loss (Gms/man/day)	107	0	78
Caloric Equivalent of Weight Loss (Calories/man/day)	374	0	273
Corrected Caloric Intake (Calories/man/day)	2661	2870	2678
Resting Energy Expenditure During 12 Daytime Hours (Calories/man)	894	1030	825

TABLE II: NUTRITIVE VALUES FOR FOODS FED IN COLD CHAMBER STUDY
(%)

	Average of 4 jams	Starch jelly bar	Hi-Calorie flavored dry milk powder	Bread	Butter
H_2O	28.73	12.90	1.00	34.73	16.03
Ash	0.21	0.02	5.26	1.91	2.74
Fat	0.63	0.39	21.88	3.36	81.12
Protein	0.32	0.04	24.50	8.23	0.51
Carbohydrate	70.11	86.65	47.36	51.82	0
Calcium, mg.	6.6	6.8	900.0	88.2	16.1
Iron, mg.	.4	0.5	1.0	1.9	—
Sodium, mg.			0.30	0.57	0.73
Caloric density, (Cal./gm.)	2.87	3.50	4.84	2.70	7.32

Table III: Morning Body Weight, (Kg)
for five men during control and cold exposure periods

Control Period, day:

Subject	7	8	9	10	11	12	13	14
1	58.75	58.45	58.29	58.59	58.32	58.27	58.37	58.21
2	65.19	65.17	65.03	64.73	64.61	64.95	65.03	64.81
3	68.74	68.63	68.75	68.91	68.60	68.54	68.48	68.56
4	88.19	88.02	88.09	88.03	87.83	87.57	87.50	87.48
5	62.82	62.65	62.47	62.38	62.30	62.23	62.15	62.13

Cold Period, day:

Subject	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	57.93	57.70	57.94	57.77	57.76	58.05	58.26	58.14	58.32	58.11	58.44	58.30	58.14	58.41
2	64.85	64.83	65.10	64.95	64.53	64.62	64.75	64.79	64.54	64.27	64.61	64.44	65.05	64.69
3	67.78	67.61	68.13	67.87	68.11	68.22	68.05	68.69	68.75	68.51	68.79	68.18	68.01	68.27
4	87.07	86.65	86.55	86.41	86.15	86.36	86.41	86.50	86.67	86.11	86.65	85.41	85.37	85.19
5	61.51	61.42	61.44	61.45	61.19	61.21	60.90	60.73	60.83	60.48	60.61	60.55	60.35	60.42

Recovery Period, day:

Subject	29	30	31	32	33	34	35	36	37	38	39	40
1	58.60	59.07	59.04	58.87	58.78	58.60	58.88	58.90	58.53	58.29	58.17	57.93
2	65.15	65.51	65.26	65.03	65.22	65.12	65.50	64.92	65.11	64.99	64.84	64.87
3	68.59	69.02	68.64	68.62	68.85	68.72	68.56	68.20	68.40	68.19	68.22	67.74
4	85.44	85.73	85.54	85.08	85.15	84.85	84.49	85.35	85.25	84.65	83.22	83.23
5	61.02	60.48	60.49	60.87	60.75	60.29	60.76	60.66	60.80	61.13	60.98	60.74

Table IV: Caloric Intake (Calories/day)
for five men during control and cold-exposure periods

Control Period, day:

Subject	7	8	9	10	11	12	13
1	2699	2181	2668	2342	2207	2345	2336
2	2397	2088	1883	2115	2440	2730	2674
3	2167	2141	2914	2170	2543	2533	2454
4	2682	2459	2332	2500	2380	2403	2420
5	1766	1763	1920	1794	1845	1589	1918

Cold Period, day:

Subject	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	2495	2947	3522	2976	2942	3419	3616	3113	3478	2687	3428	3449	3581	2968
2	2947	3415	3042	3077	2095	2653	3099	2958	2605	2088	2830	3089	2668	2651
3	2411	2787	3727	3113	3517	3547	3506	4178	3646	3141	3455	2960	3703	3032
4	2366	2875	3197	2733	2072	2586	2696	3270	3159	2798	2022	2496	2239	2325
5	2257	2497	2620	2365	1831	2244	2205	2423	1955	1944	2180	2262	2625	2089

Recovery Period, day:

Subject	28	29	30	31	32	33	34	35	36	37	38	39
1	3153	3042	2830	2915	2372	2251	3186	2703	2654	2670	2887	2114
2	2357	2720	2963	2542	2505	2982	3237	2327	2432	2734	1710	2418
3	2236	2585	2558	2592	2680	2598	2735	2464	2502	2278	2715	2146
4	1981	1904	2260	1970	1970	2245	2154	2462	2534	2256	1366	2279
5	1939	1146	2024	1845	2055	2150	2264	2171	2417	2600	2330	2178

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